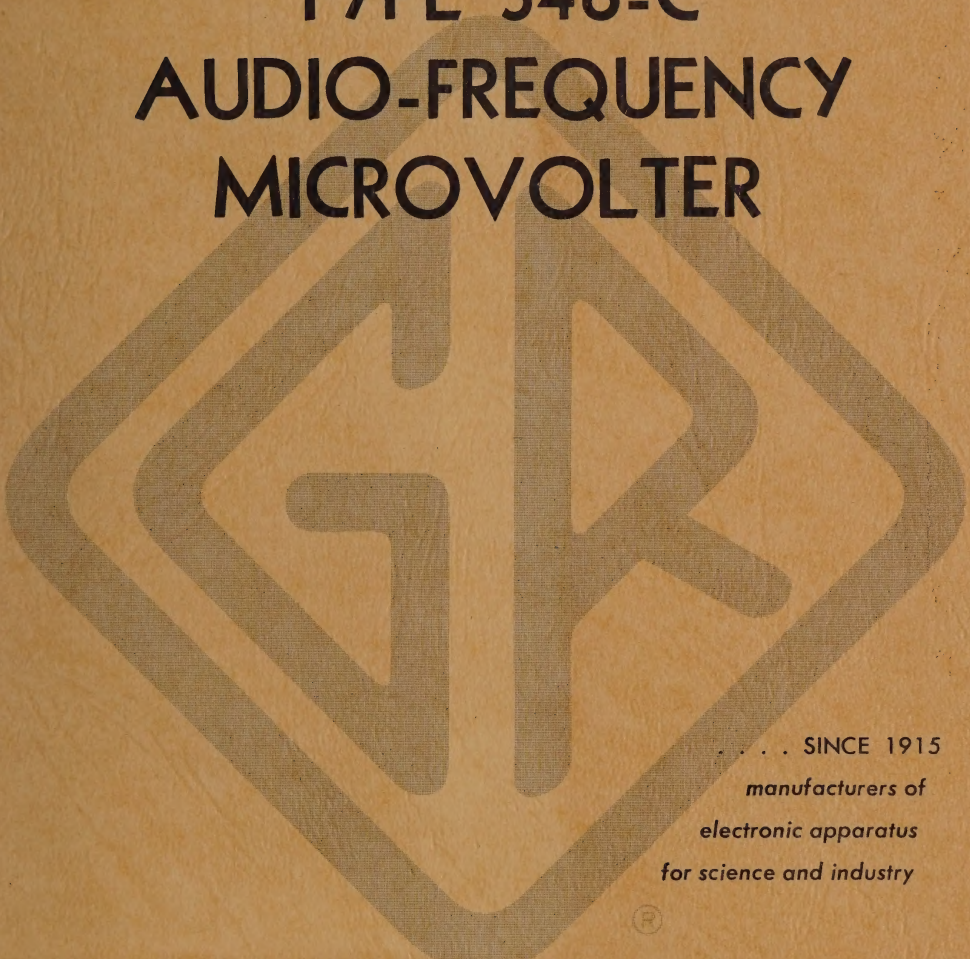
OPERATING INSTRUCTIONS

B-16

TYPE 546-C AUDIO-FREQUENCY MICROVOLTER



. . . . SINCE 1915

manufacturers of

electronic apparatus

for science and industry

GENERAL RADIO COMPANY

CAMBRIDGE 39, MASSACHUSETTS, USA

344-K

OPERATING INSTRUCTIONS

TYPE 546-C AUDIO-FREQUENCY MICROVOLTER

Form 344-K
August, 1958

GENERAL RADIO COMPANY

CAMBRIDGE 39 MASSACHUSETTS

SPECIFICATIONS

Output Voltage Range:	0.5 μv to 1.0 v, with 2.2-v input voltage.
Accuracy:	For open-circuit output voltages the calibration is accurate within $\pm$(3% + 0.5 μv) for output settings above 1 μv and for all frequencies between 20 and 20,000 cps. For frequencies up to 100 kc the calibration is accurate within $\pm$5% for output settings above 100 μv. These specifications apply only where waveform and temperature errors are negligible (see below). In calculating ratios of output voltages at a given frequency, the accuracy of any given reading can be considered to be within $\pm$(2% + 0.5 μv), at frequencies up to 100,000 cps. At frequencies above 20 kc this accuracy applies only at levels above 100 μv.
Output Impedance:	Approximately 600 ohms and is constant with setting within $\pm$5%. This impedance is low enough so that no correction on output voltage is necessary for load impedances of the order of 100,000 ohms or more.
Input Impedance:	Approximately 600 ohms, substantially independent of output setting on all but the highest multiplier setting.
Waveform Error:	Refer to paragraph 3.4.
Temperature Error:	Refer to paragraph 3.3.
Power Source:	The driving oscillator must be able to supply about 2.2 v across 600 ohms, or about 8 mw.
Terminals:	Jack-top binding posts with standard 3/4-in. spacing.
Dimensions:	Length 10 in., width 7-1/8 in., height 6-1/8 in., over-all.
Weight:	6-1/2 lb.

GENERAL RADIO EXPERIMENTER reference: Volume XXIII No. 1, June, 1948.

OPERATING INSTRUCTIONS
FOR
TYPE 546-C
MICROVOLTER

Form 344-J

GENERAL RADIO COMPANY

CAMBRIDGE 39 MASSACHUSETTS

NEW YORK CHICAGO LOS ANGELES

U. S. A.

OPERATING INSTRUCTIONS
FOR
TYPE 546-C
MICROVOLTER

PART 1
DESCRIPTION

The Type 546-C Microvolter, when used with a suitable oscillator, becomes a 600-ohm source of accurately-known audio-frequency potentials. The output voltage ranges from 1 volt to less than 1 microvolt, and its magnitude is directly indicated by a dial and multiplier switch. Voltages below 1 microvolt are obtainable with a sacrifice in accuracy.

Since the microvolter is a convenient means for adjusting the output of an oscillator to a small, accurately-known value, it has a use in most measurements on audio-frequency circuits. In the broadcast or sound studio it is convenient for measuring transmission loss and frequency response characteristics on circuits and for checking the over-all performance between the speech circuits and the antenna. It is suitable for measuring amplifier gain and for calibrating amplifiers for use as microvoltmeters.

PART 2
OPERATION

Connect the INPUT terminals to a suitable source of audio-frequency power. Adjust the source voltage until the voltmeter indicates 0 db (2.2 volts). The input impedance is approximately 600 ohms. It will be noticed from the wiring diagram that the variation of input resistance as the multiplier switch is turned is compensated by the shunt resistor section of the switch shown in the upper left corner of the circuit diagram.

Sources of lower power can be utilized by maintaining a reference voltage of less than 2.2 volts, in which case the microvolter output voltages are less than their indicated values by the ratio of the reference voltage to 2.2 volts (for example, 1/2 for a 1.1-volt reference), or the meter reading in db can be added algebraically to the dial readings in db. The accuracy of absolute voltage values is poorer under these conditions, however.

Connect the OUTPUT terminal marked "G" to the low potential side of the power source and, where possible, this common connection should be grounded.

For all ordinary measurement purposes the OUTPUT terminals can be considered the terminals of a 600-ohm generator having the open-circuit terminal voltage indicated by the dial and the setting of the MULTIPLIER. More accurate results will, in general, be obtained by setting the multiplier switch so that the desired voltage is obtained for dial settings lying between 1 and 10.

When the microvolter is used to supply a 600-ohm load, the output dbm (decibels above 1 milliwatt) can be obtained from the "db above 1 microvolt" reading of the microvolter by subtracting 123.8 db.

CAUTION - Never connect the microvolter OUTPUT terminals across a circuit carrying current, either a-c or d-c, to avoid getting erroneous readings on the voltmeter. Should the drop across the output terminals exceed 4 volts, the microvolter may be permanently damaged.

If the input voltage is not a pure sine wave, the resultant error for absolute measurements can be nearly as great as the percentage of harmonics present.

For low-voltage output (around 10 μv) a shielded oscillator and cap-shielded leads should be used.

PART 3
PERFORMANCE CHARACTERISTICS

GENERAL The Type 546-C Microvolter is built for use without calibration charts or correction curves, and, when so used, its accuracy is more than sufficient for most measurements. Where unusual accuracy is required or where the limits of error must be known, the following discussion can be consulted.

ACCURACY For open-circuit output voltages the calibration is accurate within $\pm$(3% + 0.5 microvolt) for output settings above 1 microvolt and for all frequencies between 20 and 20,000 cycles. For higher frequencies up to 100 kc, the calibration is accurate within $\pm$5% for output settings above 100 microvolts. These specifications apply only where waveform and temperature errors are negligible (see below)

In calculating ratios of output voltages, at a given frequency, the accuracy of any given reading can be considered to be within $\pm$(2% + 0.5 microvolt), at frequencies up to 100,000 cycles. At the higher frequencies, this accuracy applies only at levels above 100 microvolts.

The errors in absolute-voltage values can be reduced to about the same amount as errors in voltage-ratio measurements, by checking the microvolter against a vacuum-tube voltmeter whose indications are known to be sufficiently accurate. Set the microvolter for 1000 millivolts output, and then adjust the input voltage until the standard voltmeter indicates 1 volt. The voltage indicated on the microvolter can then be maintained at the value thus obtained. This check can, if desired, be repeated for different frequencies and for different operating temperatures.

The microvolter can be used on dc if an external meter is used.

TEMPERATURE ERROR Any initial error which may be present in the indicating meter has been compensated for in the calibration of the OUTPUT dial. As with all copper-oxide instruments, the meter indication is somewhat affected by temperature variations. The calibration is correct at 77° F., and for room temperatures below this value the correction is -.0046 volts per degree F. For operating temperatures above 77° F., the correction is +.0023 volts per degree F. These corrections are to be applied to the 2.2-volt setting to obtain the correct setting at the operating temperature. For example, at a temperature of 97° F., the meter indication for standard input is 2.246 volts. The accuracy of the calibration is independent of temperature when the microvolter is used as an attenuator or voltage divider.

WAVEFORM ERROR The accuracy of the microvolter as a calibrated attenuator or voltage divider is independent of waveform. The absolute accuracy of the output voltage calibration depends on the characteristics of the input copper-oxide rectifier voltmeter, which has a small waveform error that depends in turn on both the phase and the magnitude of harmonics present in the input. This error in the voltmeter can, in general, be neglected when the microvolter is used with ordinary laboratory oscillators. The rectifier-type voltmeter itself introduces some distortion unless the source impedance is very low. With a 600-ohm source the distortion introduced is about 0.2%.

OUTPUT IMPEDANCE Since the microvolter indicates open-circuit voltage, the internal output impedance must be taken into account when working into low-impedance loads. For loads greater than 100,000 ohms no correction need be made.

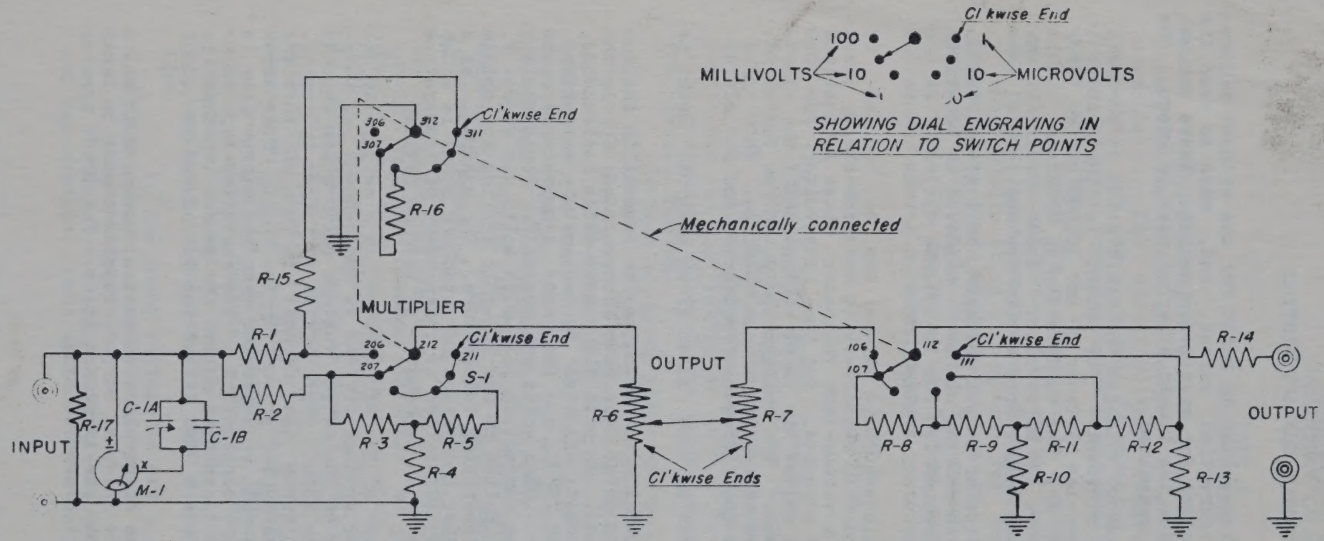


FIGURE 1. Wiring Diagram for Type 546-C Audio-Frequency Microvolter

PARTS LIST

Resistors

R-1	= 400 Ω	±0.25%	R-9	= 178 Ω	±0.25%
R-2	= 4 kΩ	±0.25%	R-10	= 22.2 Ω	±0.5%
R-3	= 400 Ω	±0.25%	R-11	= 178 Ω	±0.25%
R-4	= 44.44 Ω	±0.25%	R-12	= 1800 Ω	±0.25%
R-5	= 356 Ω	±0.25%	R-13	= 200 Ω	±0.25%
R-6	= 420-440 Ω		R-14	= 418 Ω	±1%
R-7	= 200 Ω	±5%	R-15	= 390 Ω	±5%
R-8	= 1800 Ω	±0.25%	R-16	= 15 Ω	±10%
			R-17	= 12 kΩ	± 10%

Capacitors

C-1A = 10-100 μμf
C-1B = 100 μμf ±10%

Meter

M-1 = 488-303B
(Weston Model 892)

Switch

S-1 = 546-321 (Yaxley)

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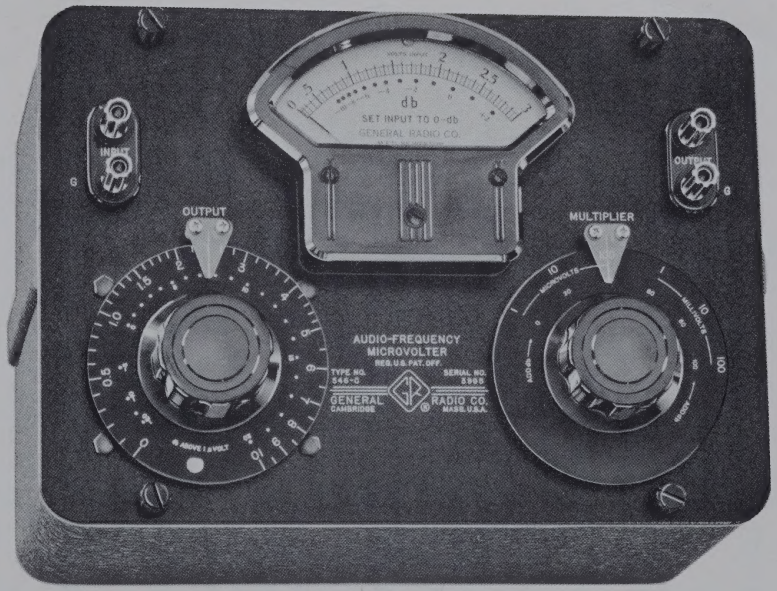

Figure 1.
Panel View, Type 546-C Audio-Frequency Microvolter.

TYPE 546-C
AUDIO-FREQUENCY MICROVOLTER

Section 1
INTRODUCTION

1.1 PURPOSE. The Type 546-C Audio-Frequency Microvolter (Figure 1) is a calibrated attenuator or voltage divider which, when used with a suitable oscillator, supplies small, accurately known audio-frequency voltages. Use of the Microvolter converts an oscillator into a standard-signal generator, valuable in such measurements as gain or loss, frequency-response characteristics, overload level, and hum level on amplifiers, networks, and other audio-frequency equipment. The combination of oscillator and Microvolter is also useful in the measurement of the generated voltage of microphones, vibration and phonograph pickups, and other transducers by the insert-voltage method. The Microvolter provides the standardizing voltmeter and the calibrated attenuator necessary to supply accurately known voltages from 0.5 microvolt to 1 volt (open circuit).

1.2 DESCRIPTION.

1.2.1 GENERAL. The Microvolter consists, essentially, of a constant-impedance attenuator and a voltmeter by which the input to the attenuator is standardized. A switch controls the output voltage in decade steps, while an individually calibrated dial provides continuous control over each decade.

1.2.2 CONTROLS. The only controls are the OUTPUT and MULTIPLIER dial-knobs, by means of which the output voltage is set. The OUTPUT control is a continuous rotary knob and dial, the latter calibrated in voltage and in decibels above 1 microvolt. The voltage scale is approximately logarithmic, and the decibel scale approximately linear. The MULTIPLIER control is a six-position rotary switch, whose dial is calibrated in decade steps from 1 microvolt to 100 millivolts. The MULTIPLIER dial is also calibrated in 20-db steps from 0 to 100 db.

A meter on the front panel indicates input in volts and in decibels.

1.2.3 CONNECTIONS. A pair of jack-top binding posts, marked INPUT, provide the connection between the source of audio-frequency voltage and the Microvolter. Another pair of similar binding posts, marked OUTPUT, are the terminals at which the voltage indicated on the dials is available.

1.3 OSCILLATOR REQUIREMENTS. An audio-frequency oscillator must be used to furnish voltage to the Microvolter. Oscillator output requirements are about 2.2 volts across 600 ohms, or about 8 milliwatts. The following General Radio oscillators are suitable:

Type 1210-C Unit R-C Oscillator
Types 1214-A, -E Unit Oscillators
Type 1301-A Low-Distortion Oscillator
Type 1303-A Two-Signal Audio Generator
Type 1304-B Beat-Frequency Audio Generator
Type 1307-A Transistor Oscillator

Section 2
OPERATING PROCEDURE

2.1 NORMAL OPERATION. To provide an audio-frequency output between 0.5 microvolt and 1 volt, proceed as follows:

a. Connect a suitable audio-frequency oscillator (refer to paragraph 1.3) to the INPUT terminals of the Microvolter.

b. Connect the INPUT terminal marked G to the low-potential side of the oscillator, and, if possible, ground this connection.

c. Vary the output of the oscillator until the Microvolter meter indicates 2.2 volts (0 db).

d. Set the OUTPUT and MULTIPLIER dials so that the product of their voltage settings equals the desired output voltage. For highest accuracy, use the portion of the OUTPUT dial between 1.0 and 10. For example, if the desired output voltage is 50 microvolts, set the OUTPUT dial to 5 and the MULTIPLIER dial to 10 MICROVOLTS. If the desired output is 70 millivolts, set the OUTPUT dial to 7 and the MULTIPLIER dial to 10 MILLIVOLTS. Output in terms of decibels above 1 microvolt is denoted by the algebraic sum of the decibel indications on the two dials. Since the reference level is 1 microvolt, almost all decibel readings will be positive throughout the range of the instrument. When the Microvolter is used to supply a 600-ohm load, the output dbm (decibels above 1 milliwatt) equals the output in decibels above 1 microvolt minus 123.8 db.

e. For all ordinary measurement purposes the OUTPUT terminals can be considered the terminals of a 600-ohm generator having the open-circuit terminal voltage indicated by the dial settings.

CAUTION

Never connect the Microvolter OUTPUT terminals across a circuit carrying current, either ac or dc. If the voltage drop at the OUTPUT terminals is over 4 volts, the Microvolter may be permanently damaged, while smaller drops may cause erroneous voltmeter indications.

f. If the output voltage is 100 microvolts or less, use a shielded oscillator and cup-shielded leads.

2.2 USE OF INPUT VOLTAGES LESS THAN 2.2 VOLTS. Since all dial markings are based on an input of 2.2 volts, an input of less than 2.2 volts would produce output voltages less than their indicated values. For instance, if the source is able to supply only 1.1 volts, the output voltage is one-half that indicated on the dials. This simple relationship is expressed:

$$E_o = \frac{E_m E_d}{2.2}$$

where: E_d = voltage indicated on dials
E_m = voltage indicated on meter
E_o = actual output voltage

Also, if reduced power input is unavoidable, the meter indication in decibels can be added algebraically to the dial decibel indications.

Although it might seem that the useful output range of the Microvolter is increased by the above methods, any such increase is achieved at the expense of accuracy.

2.3 D-C VOLTAGES. The Microvolter can be used on direct current if an external meter is used to measure the input voltage.

2.4 MEASUREMENT OF UNKNOWN VOLTAGES.

2.4.1 GENERAL. The Microvolter can be used to measure unknown voltages either directly by means of the Microvolter or by substitution methods. Voltmeter errors (refer to Section 3) must be considered when the Microvolter meter is used to indicate directly voltage applied to the INPUT terminals.

2.4.2 SUBSTITUTION METHOD. In the substitution method, an unknown voltage can be fed into an external, high-impedance meter, and the deflection noted. With the input to the Microvolter at 2.2 volts, the Microvolter output can be fed into the same meter, and the dials adjusted to produce the same deflection. The Microvolter dial settings will then indicate the unknown voltage. If necessary, connect a resistor in series with the external meter to produce a high input impedance.

2.4.3 INSERT-VOLTAGE METHOD. Several measurement techniques using the insert-voltage method can be devised, but the following example will serve to demonstrate the principles involved. Connect the source of the voltage to be measured, the Microvolter, an amplifier, and an external meter as shown in Figure 2. Set the Microvolter dial to zero and supply the unknown voltage to the external meter, noting the deflection. Then, with the unknown remaining in circuit but not supplying any voltage, vary

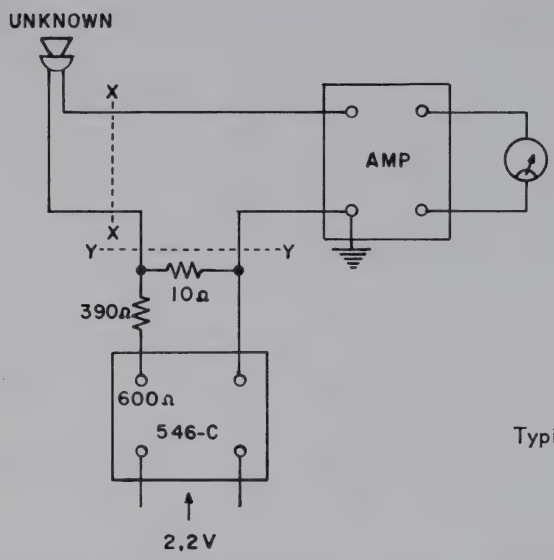

Figure 2.
Typical Measurement Setup Using
Insert-Voltage Method.

the Microvolter dials to produce the same deflection on the external meter as noted before. (The Microvolter should be operating with an input of 2.2 volts.) With the impedance values shown in the diagram, the unknown voltage will be $\frac{10}{600 + 390 + 10}$ or 1/100 of that indicated on the Microvolter dials, since this gives the equivalent open-circuit voltage from the Microvolter across Y-Y in the diagram. The voltage measured is the equivalent open-circuit voltage across X-X in the diagram.

For the circuit arrangement shown in Figure 2, it is essential that the unknown be operated ungrounded, so that the 10-ohm calibration resistor is not shorted by multiple grounds. Any stray capacitance to ground should be kept sufficiently low so that the shunting effect on the 10-ohm resistor is negligible.

Section 3
ERRORS AND CORRECTIONS

3.1 GENERAL. The Microvolter is designed for use without calibration charts or correction curves, and its accuracy is more than sufficient for most measurements. Where extremely high accuracy is required or where the limits of error must be known, the following information should prove helpful.

3.2 OVER-ALL ACCURACY. For output settings above 1 microvolt at frequencies from 20 to 20,000 cps, the open-circuit output-voltage cali-

bration is accurate to within ±(3% + 0.5 microvolt). At frequencies up to 100 kc the calibration is accurate to within ±5% for output settings above 100 microvolts. These specifications apply only when waveform and temperature errors are negligible (refer to paragraphs 3.3 and 3.4).

In calculating ratios of output voltages at a given frequency, the accuracy of any given reading can be considered to be within ±(2% + 0.5 microvolt), at frequencies up to 100 kc. At frequencies above 20 kc this accuracy applies only at output levels above 100 microvolts.

To reduce errors in absolute-voltage values, check the Microvolter against an accurate vacuum-tube voltmeter, such as the General Radio Type 1800-B or 1803-B. Set the Microvolter for an output of 1000 millivolts, and adjust the input voltage to the Microvolter until the vacuum-tube voltmeter indicates 1 volt. Thus, if the input to the Microvolter is maintained, output voltages will be as indicated on the Microvolter dials. This check can be repeated for different frequencies and operating temperatures.

3.3 TEMPERATURE ERROR. Any initial error that may be present in the indicating meter has been compensated for by calibration of the OUTPUT dial. As with all copper-oxide instruments, the meter is somewhat affected by temperature variations. Calibration is correct at 77 degrees F. For room temperatures below this value the correction is -0.0046 volt per degree F. For temperatures above 77 degrees F, the correction is +0.0023 volt per degree F. These corrections should be applied to the normal 2.2-volt meter indication to obtain the correct indication at the operating temperature. For example, if the temperature is 97 degrees F, the correction is +0.0023 (97-77), or 0.046 volt. This correction, added to the standard meter indication of 2.2 volts, gives a corrected meter setting of 2.246 volts. The accuracy of the calibration is independent of temperature when the Microvolter is used as an attenuator or voltage divider.

3.4 WAVEFORM ERROR. The accuracy of the Microvolter as a calibrated attenuator or voltage divider is independent of waveform. However, the absolute accuracy of the output voltage calibration depends on the characteristics of the input copper-oxide rectifier voltmeter, which has a waveform error that depends in turn on both the phase and the magnitude of harmonics present in the input. If the input voltage is not a pure sine wave, the resultant error for absolute measurements can be nearly as great as the percentage of harmonics present. This error can usually be overlooked when the Microvolter is used with ordinary laboratory oscillators. The rectifier-type voltmeter itself introduces some distortion unless the source impedance is very low. With a source impedance of 600 ohms the distortion introduced is about 0.2 percent.

3.5 OUTPUT IMPEDANCE. Since the Microvolter indicates open-circuit voltages, the internal output impedance must be taken into account with low-impedance loads. For loads greater than 100,000 ohms no correction need be made.

Section 4
SERVICE AND MAINTENANCE

4.1 GENERAL. Any major service problems should be referred to our Service Department, which will cooperate as much as possible by furnishing information as well as by supplying any replacement parts needed.

When notifying our Service Department of any difficulties in the operation or service of the instrument, specify the serial and type numbers of the instrument. Also give a complete report of trouble encountered, and steps taken to eliminate the trouble. Before returning an instrument or parts for repair, please write to our Service Department requesting a Returned Material Tag, which includes shipping instructions. Use of this tag will insure proper handling and identification. A purchase order covering repair of material returned should also be forwarded to avoid unnecessary delay.

4.2 POTENTIOMETER ELECTRICAL NOISE. Occasionally, rotation of the OUTPUT control may cause some electrical noise. This condition can be alleviated if the control is rapidly swept back and forth a few times.

4.3 PARTS LIST:

REF DESIG	DESCRIPTION	GR PART NO.
C1A	CAPACITOR, Trimmer, 10-100μμf, 500 dcwv	COT-24
C1B	CAPACITOR, Mica, 100μμf ±10%	COM-20B
M1	METER (Weston Model 892)	488-303B
R1	RESISTOR, 400Ω ±0.25%	
R2	RESISTOR, 4 k ±0.25%	546-302
R3	RESISTOR, 400Ω ±0.25%	
R4	RESISTOR, 44.44Ω ±0.25%	546-303
R5	RESISTOR, 356Ω ±0.25%	
R6	RESISTOR, 420-440Ω	546-30
R7	RESISTOR, 200Ω ±5%	
R8	RESISTOR, 1800Ω ±0.25%	
R9	RESISTOR, 178Ω ±0.25%	546-304
R10	RESISTOR, 22.2Ω ±0.5%	
R11	RESISTOR, 178Ω 0.25%	
R12	RESISTOR, 1800Ω ±0.25%	546-305
R13	RESISTOR, 200Ω ±0.25%	
R14	RESISTOR, Film, 418Ω ±1%, 1/2 w	REF-1
R15	RESISTOR, Wire-wound, 390Ω ±5%, 1/2 w	REW-3C
R16	RESISTOR, Wire-wound, 15Ω ±10%, 1/2 w	REW-3C
R17	RESISTOR, Composition, 12 k ±10%, 1/2 w	REC-20BF
S1	SWITCH	546-321

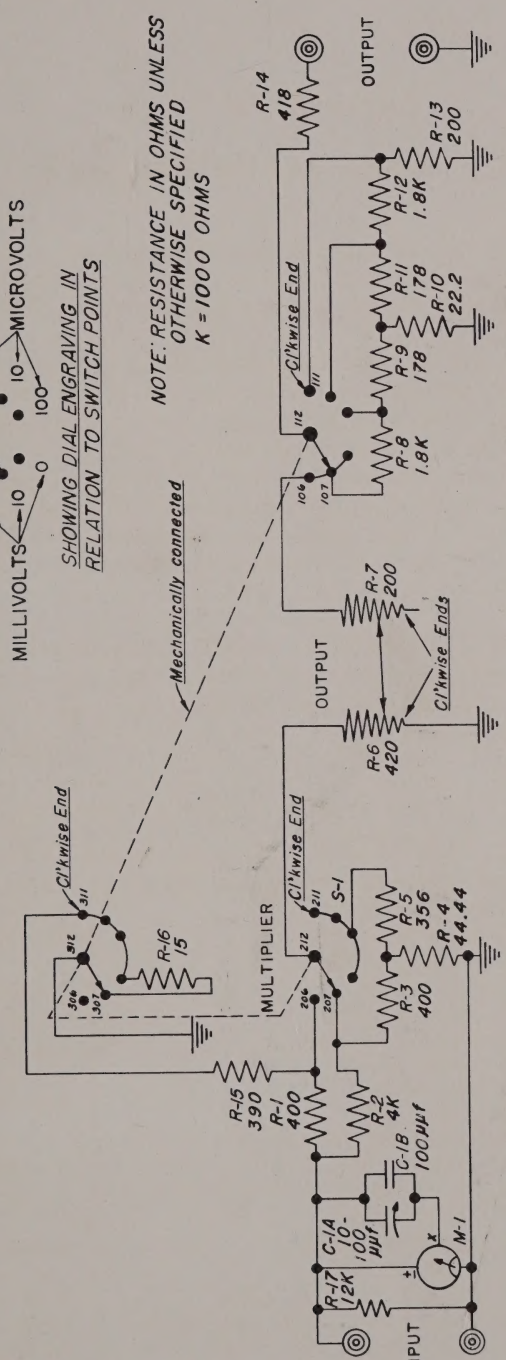

Figure 3.

Schematic Diagram for Type 546-C Audio-Frequency Microvolter.

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